Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

17-AMRP-0039

NOV 29 2016

Ms. Alexandra K. Smith, Program Manager
Nuclear Waste Program
Washington State Department of Ecology
3100 Port of Benton Boulevard
Richland, Washington 99354

Dear Ms. Smith:

SUBMITTAL OF VISUAL SAMPLING PLAN (VSP) DATA ANALYSIS REPORT FOR 207-A SOUTH RETENTION BASINS PER PERMIT CONDITION V.5.B.2

This letter transmits the subject report in accordance with condition V.5.B.2 of the Hanford Facility Dangerous Waste permit for the 207-A South Retention Basins which became effective on November 5, 2016. The report confirms that sampling assumptions were met and that the null hypothesis was rejected for all target analytes (i.e., the site meets the cleanup criteria for clean closure).

Data from sampling has been determined to be usable for decision making via the data validation report and the data quality assessment that will be provided with the certification of closure in accordance with section 4.9 of the approved closure plan. As previously communicated to your staff, all sample results were flagged with 'U' indicating the analyte was tested for but not detected, or with 'J' indicating that the analyte was tested for and detected but the reported value is estimated because of a quality control deficiency identified during the laboratory review. In both cases the data is considered usable for decision making purposes. For purposes of applying the statistical tests for clean closure, the laboratory minimum detection limit was used for the undetected results and the estimated value was used for the 'J' flagged results. For purposes of determining the 95 percent upper confidence level on the mean, the non-parametric value was used. The most restrictive cleanup level from table 5 of the approved closure plan was used. The following table provides a summary of the data:

Target Analyte	Maximum result (ug/kg)	95 percent UCL Mean (ug/kg)	Cleanup Level (ug/kg)
Acetone	4.04	3.43	2.89E+04
Methylene chloride	6.73	3.03	21.5
m-cresol	113	109	4.00E+06
o-cresol	113	109	2.33E+03
p-cresol	113	109	8.00E+06

Results from applying the 3-part test for demonstrating compliance with the Model Toxic Control Act (MTCA) clean closure level are provided below:

Test 1: The upper one-sided ninety-five percent confidence limit on the true mean soil concentration shall be less than the MTCA Method B soil cleanup level.
Result: Analytical results for all target analytes are at least one order of magnitude less than the most restrictive cleanup level.

Test 2: No sample concentration can be more than twice the cleanup level.
Result: All results were below the cleanup level.

Test 3: Less than 10 percent of the samples can exceed the cleanup level.
Result: All results were below the cleanup level.

If you have any questions please contact me, or your staff may contact, Al Farabee of my staff, on (509) 376-8089.

Sincerely,

Ray J. Corey, Assistant Manager
for the River and Plateau

AMRP:RLL

Attachment

cc w/attach:
D. J. Alexander, Ecology
G. Bohnee, NPT
R. Buck, Wanapum
L. J. Cusack, CHPRC
S. L. Dahl-Crumpler, Ecology
B. J. Dixon, CHPRC
D. A. Faulk, EPA
S. Hudson, HAB
M. N. Jaraysi, CHPRC
R. Jim, YN
N. M. Menard, Ecology
K. Niles, ODOE
D. Rowland, YN
R. Skeen, CTUIR
Administrative Record
Ecology NWP Library
Environmental Portal
HF Operating Record (J. K. Perry, MSA)

207-A South Retention Basin Clean Closure
Visual Sample Plan (VSP) Report
Summary Statistics comparing Sample Results to Design Assumptions

Systematic sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Systematic with a random start location
Working (Null) Hypothesis	The median (mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated total number of samples	20
Number of samples on map [a]	20
Number of selected sample areas [b]	1
Specified sampling area [c]	1,313.6 m^2 (14140.00 ft^2)
Size of grid / Area of grid cell [d]	28.5722 m / 707 m^2 (93.7 ft / 7,610 ft^2)
Grid pattern	Triangular
Total cost of sampling [e]	$0.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.

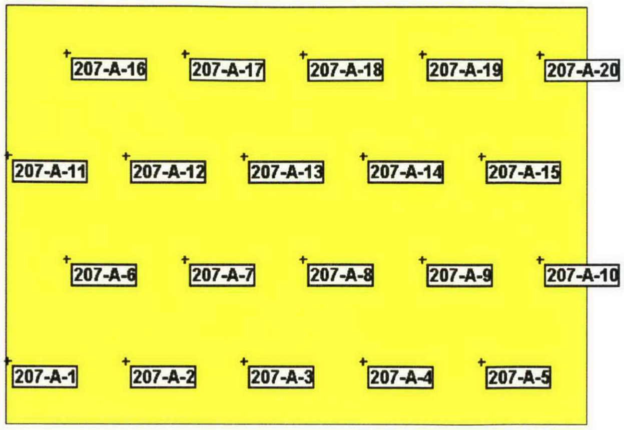
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.

[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.

[d] Size of grid / Area of grid cell gives the linear and square dimensions of the grid used to systematically place samples.

[e] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.

Area: 207-A South Retention Basin Values Shown for Acetone			
X Coord	Y Coord	Label	Value
0.2535	15.1433	207-A-1	3.42
28.8257	15.1433	207-A-2	3.09
57.3980	15.1433	207-A-3	3.36
85.9702	15.1433	207-A-4	3.06
114.5425	15.1433	207-A-5	3.22
14.5396	39.8876	207-A-6	3.22
43.1119	39.8876	207-A-7	3.27
71.6841	39.8876	207-A-8	3.23
100.2564	39.8876	207-A-9	3.18
128.8286	39.8876	207-A-10	3.12
0.2535	64.6318	207-A-11	2.72
28.8257	64.6318	207-A-12	3.15
57.3980	64.6318	207-A-13	3.09
85.9702	64.6318	207-A-14	3.14
114.5425	64.6318	207-A-15	3.08
14.5396	89.3761	207-A-16	4.04
43.1119	89.3761	207-A-17	3.10
71.6841	89.3761	207-A-18	3.26
100.2564	89.3761	207-A-19	3.05
128.8286	89.3761	207-A-20	2.74



Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median (mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median (mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points over a systematic grid with a random start ensures spatial coverage of the site. Statistical analyses of systematically collected data are valid if a random start to the grid is used. One disadvantage of systematically collected samples is that spatial variability or patterns may not be discovered if the grid spacing is large relative to the spatial patterns.

Number of Total Samples: Calculation Equation and Inputs

The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median (mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2} \qquad \text{where} \qquad SignP = \Phi\left(\frac{\Delta}{S_{total}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),

n is the number of samples,

S_{total} is the estimated standard deviation of the measured values including analytical error,

Δ is the width of the gray region,

α is the acceptable probability of incorrectly concluding the site median (mean) is less than the threshold,

β is the acceptable probability of incorrectly concluding the site median (mean) exceeds the threshold,

$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,

$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n[a]	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ [b]	$Z_{1-\beta}$ [c]
Acetone	20	0.45 µg/kg	0.4 µg/kg	0.05	0.2	1.64485	0.841621
Methylene chloride	20	0.45 µg/kg	0.4 µg/kg	0.05	0.2	1.64485	0.841621
2-Methylphenol (cresol, o-)	20	0.45 µg/kg	0.4 µg/kg	0.05	0.2	1.64485	0.841621
3+4 Methylphenol (cresol, m+p)	20	0.45 µg/kg	0.4 µg/kg	0.05	0.2	1.64485	0.841621

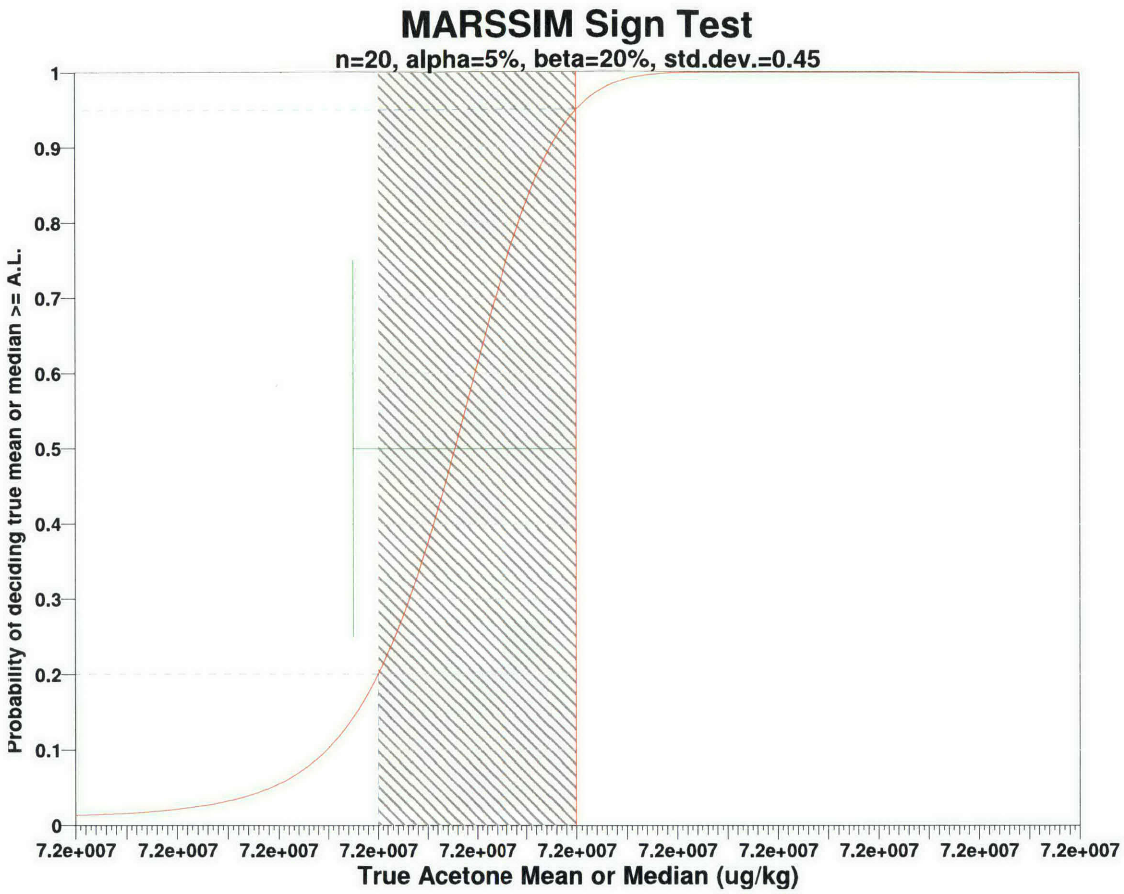
[a] The final number of samples has been increased by the MARSSIM Overage of 20%.

[b] This value is automatically calculated by VSP based upon the user defined value of α.

[c] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median (mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at 1-α on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected probabilistically.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the gridded sample locations were selected based on a random start.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=7.2e+007		α=5		α=10		α=15	
		s=0.9	s=0.45	s=0.9	s=0.45	s=0.9	s=0.45
LBGR=90	β=15	10	10	8	8	6	6
	β=20	9	9	6	6	5	5
	β=25	8	8	5	5	4	4
LBGR=80	β=15	10	10	8	8	6	6
	β=20	9	9	6	6	5	5
	β=25	8	8	5	5	4	4
LBGR=70	β=15	10	10	8	8	6	6
	β=20	9	9	6	6	5	5
	β=25	8	8	5	5	4	4

Where:

s = Standard Deviation

LBGR = Lower Bound of Gray Region (% of Action Level)

β = Beta (%), Probability of mistakenly concluding that μ > action level

α = Alpha (%), Probability of mistakenly concluding that μ < action level

AL = Action Level (Threshold) = 7.20E+04 mg/kg (7.2E+-7 µg/kg)

Analysis of the individual analytes follows.

Acetone

Data Analysis for Acetone

The following data points were entered by the user for analysis.

Acetone (µg/kg)										
Rank	1	2	3	4	5	6	7	8	9	10
0	2.72	2.74	3.05	3.06	3.08	3.09	3.09	3.1	3.12	3.14
10	3.15	3.18	3.22	3.22	3.23	3.26	3.27	3.36	3.42	4.04

SUMMARY STATISTICS for Acetone	
n	20
Min	2.72
Max	4.04
Range	1.32
Mean	3.177
Median	3.145
Variance	0.069727
StdDev	0.26406
Std Error	0.059045
Skewness	1.5227
Interquartile Range	0.17

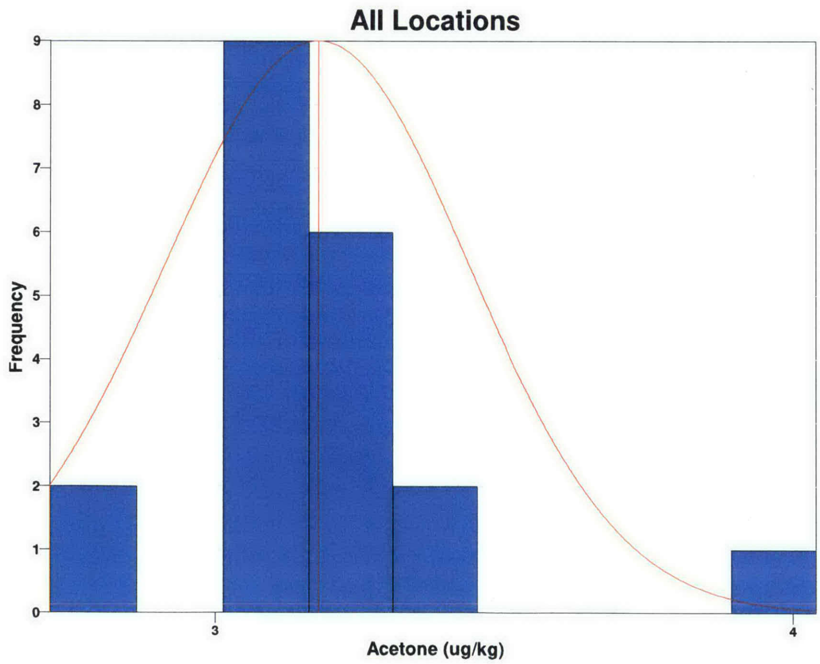
Percentiles								
1%	5%	10%	25%	50%	75%	90%	95%	99%
2.72	2.721	2.771	3.083	3.145	3.252	3.414	4.009	4.04

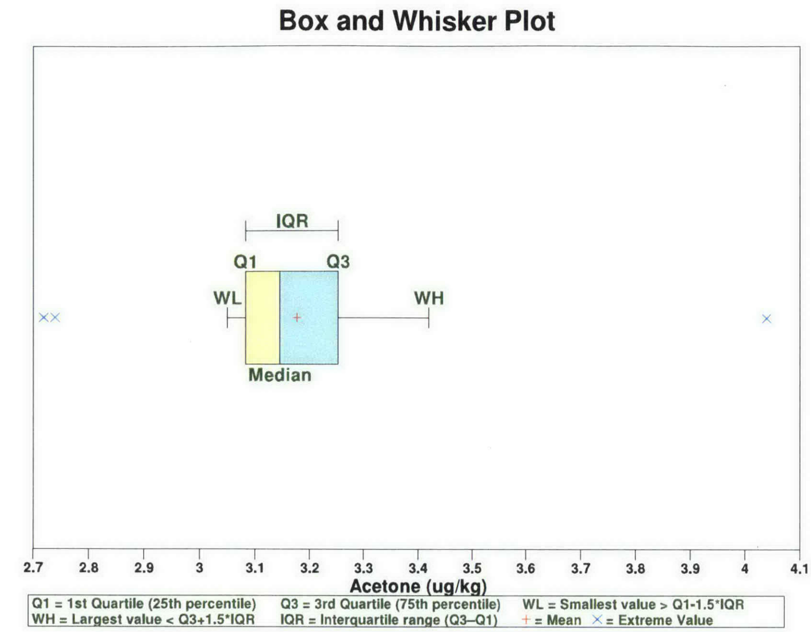
Data Plots
Three graphical displays of the data are shown below: the Histogram, the Box and Whiskers plot, and the Quantile-Quantile (Q-Q) plot.

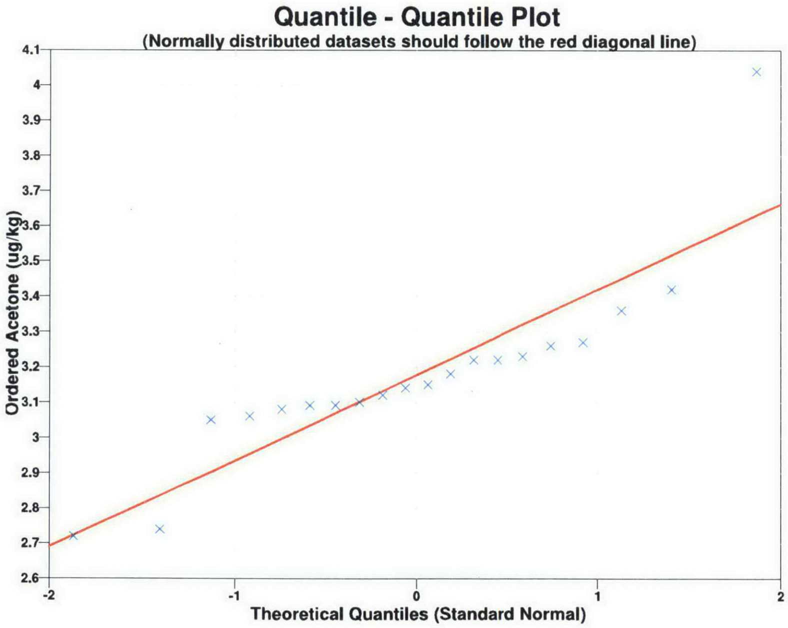
The Histogram is a plot of the fraction of the n observed data that fall within specified data "bins." A histogram is generated by dividing the x axis (range of the observed data values) into "bins" and displaying the number of data in each bin as the height of a bar for the bin. The area of the bar is the fraction of the n data values that lie within the bin. The sum of the fractions for all bins equals one. A histogram is used to assess how the n data are distributed (spread) over their range of values. If the histogram is more or less symmetric and bell shaped, then the data may be normally distributed.

The Box and Whiskers plot is composed of a central box divided by a line, and with two lines extending out from the box, called the "whiskers". The line through the box is drawn at the median of the n data observed. The two ends of the box represent the 25th and 75th percentiles of the n data values, which are also called the lower and upper quartiles, respectively, of the data set. The sample mean (mean of the n data) is shown as a "+" sign. The upper whisker extends to the largest data value that is less than the upper quartile plus 1.5 times the interquartile range (upper quartile minus the lower quartile). The lower whisker extends to the smallest data value that is greater than the lower quartile minus 1.5 times the interquartile range. Extreme data values (greater or smaller than the ends of the whiskers) are plotted individually. A Box and Whiskers plot is used to assess the symmetry of the distribution of the data set. If the distribution is symmetrical, the box is divided into two equal halves by the median, the whiskers will be the same length, and the number of extreme data points will be distributed equally on either end of the plot.

The Q-Q plot graphs the quantiles of a set of n data against the quantiles of a specific distribution. We show here only the Q-Q plot for an assumed normal distribution. The pth quantile of a distribution of data is the data value, x_p, for which a fraction p of the distribution is less than x_p. If the data plotted on the normal distribution Q-Q plot closely follow a straight line, even at the ends of the line, then the data may be assumed to be normally distributed. If the data points deviate substantially from a linear line, then the data are not normally distributed.







For more information on these three plots consult Guidance for Data Quality Assessment, EPA QA/G-9, pgs 2.3-1 through 2.3-12. (http://www.epa.gov/quality/qa-docs.html).

Tests for Acetone

A goodness-of-fit test was performed to test whether the data set had been drawn from an underlying normal distribution. The Shapiro-Wilk (SW) test was used to test the null hypothesis that the data are normally distributed. The test was conducted at the 5% significance level, i.e., the probability the test incorrectly rejects the null hypothesis was set at 0.05.

NORMAL DISTRIBUTION TEST	
Shapiro-Wilk Test Statistic	0.8163
Shapiro-Wilk 5% Critical Value	0.905

The calculated SW test statistic is less than the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the data are normal, or in other words the data do not appear to follow a normal distribution at the 5% level of significance. The Q-Q plot displayed above should be used to further assess the normality of the data.

Upper Confidence Limit on the True Mean
Two methods were used to compute the upper confidence limit (UCL) on the mean. The first is a parametric method that assumes a normal distribution. The second is the Chebyshev method, which requires no distributional assumption.

UCLs ON THE MEAN	
95% Parametric UCL	3.2791
95% Non-Parametric (Chebyshev) UCL	3.4344

Because the data do not appear to be normally distributed according to the goodness-of-fit test performed above, the non-parametric UCL (3.434) may be a more accurate upper confidence limit on the true mean.

MARSSIM Sign Test
The Sign test was performed in accordance with the guidance given in section 8.3.2 of MARSSIM. Each measurement was subtracted from the action level to obtain *n* differences $d_i = AL - X_i$. Any differences of zero were discarded from consideration and the sample size was reduced accordingly. The test statistic S+ was calculated by counting the positive differences. S+ was then compared with the critical value *k*, which was obtained from Table I.3 in Appendix I of MARSSIM.

If $S+ > k$, then the null hypothesis is rejected.

MARSSIM SIGN TEST		
Test Statistic S+	**95% Critical Value**	**Null Hypothesis**
20	14	Reject

The test rejected the null hypothesis for acetone that the mean value at the site exceeds the threshold, so conclude the **site is clean**.

Methylene chloride

Data Analysis for Methylene chloride
The following data points were entered by the user for analysis.

Methylene chloride (µg/kg)										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	1.45	1.46	1.63	1.63	1.64	1.65	1.65	1.65	1.67	1.67
10	1.68	1.7	1.72	1.72	1.72	1.74	1.74	1.79	1.82	6.73

SUMMARY STATISTICS for Methylene chloride	
n	20
Min	1.45
Max	6.73

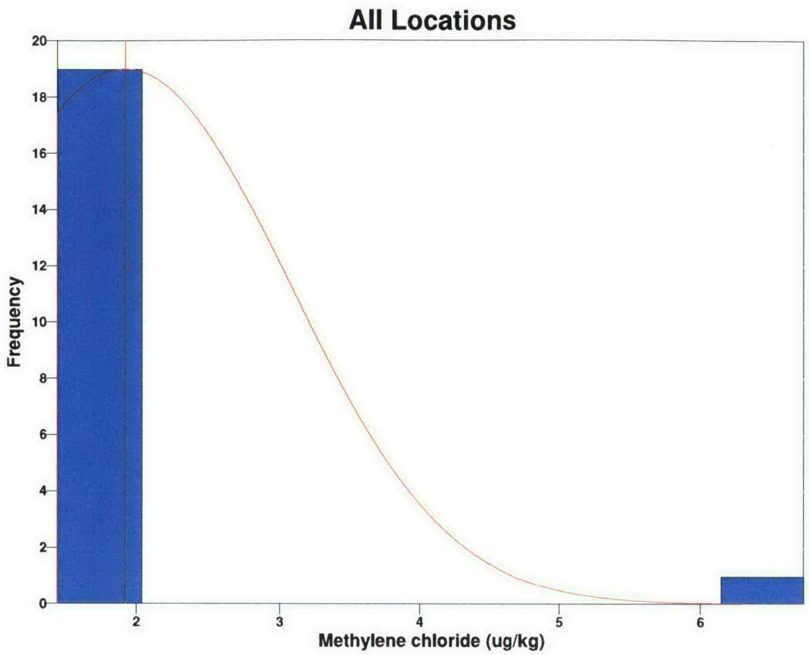
Range				5.28				
Mean				1.923				
Median				1.675				
Variance				1.2882				
StdDev				1.135				
Std Error				0.25379				
Skewness				4.4251				
Interquartile Range				0.0925				
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
1.45	1.45	1.477	1.642	1.675	1.735	1.817	6.484	6.73

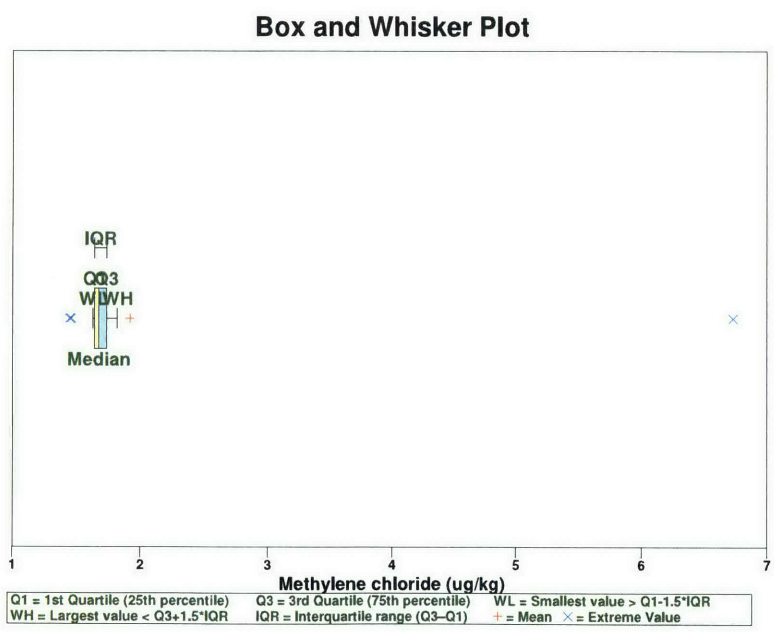
Data Plots
Three graphical displays of the data are shown below: the Histogram, the Box and Whiskers plot, and the Quantile-Quantile (Q-Q) plot.

The Histogram is a plot of the fraction of the n observed data that fall within specified data "bins." A histogram is generated by dividing the x axis (range of the observed data values) into "bins" and displaying the number of data in each bin as the height of a bar for the bin. The area of the bar is the fraction of the n data values that lie within the bin. The sum of the fractions for all bins equals one. A histogram is used to assess how the n data are distributed (spread) over their range of values. If the histogram is more or less symmetric and bell shaped, then the data may be normally distributed.

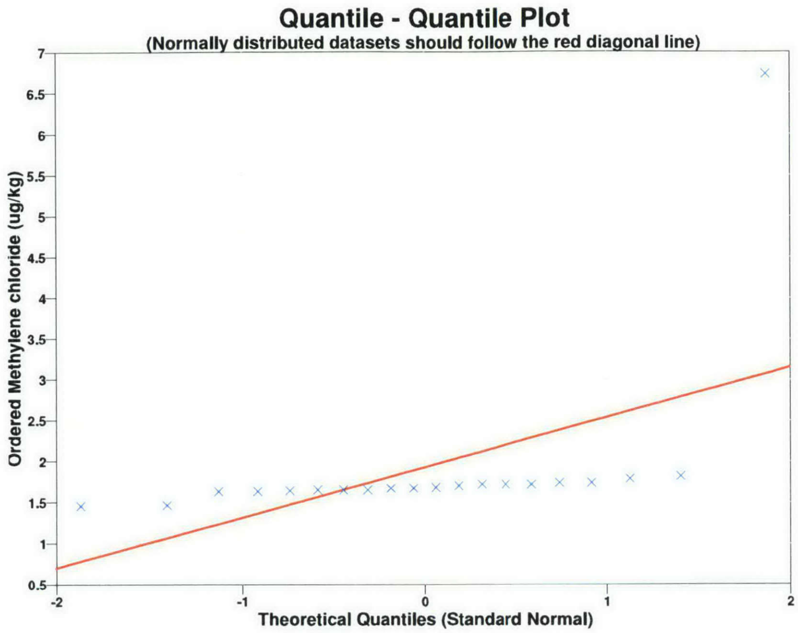
The Box and Whiskers plot is composed of a central box divided by a line, and with two lines extending out from the box, called the "whiskers". The line through the box is drawn at the median of the n data observed. The two ends of the box represent the 25th and 75th percentiles of the n data values, which are also called the lower and upper quartiles, respectively, of the data set. The sample mean (mean of the n data) is shown as a "+" sign. The upper whisker extends to the largest data value that is less than the upper quartile plus 1.5 times the interquartile range (upper quartile minus the lower quartile). The lower whisker extends to the smallest data value that is greater than the lower quartile minus 1.5 times the interquartile range. Extreme data values (greater or smaller than the ends of the whiskers) are plotted individually. A Box and Whiskers plot is used to assess the symmetry of the distribution of the data set. If the distribution is symmetrical, the box is divided into two equal halves by the median, the whiskers will be the same length, and the number of extreme data points will be distributed equally on either end of the plot.

The Q-Q plot graphs the quantiles of a set of n data against the quantiles of a specific distribution. We show here only the Q-Q plot for an assumed normal distribution. The pth quantile of a distribution of data is the data value, x_p, for which a fraction p of the distribution is less than x_p. If the data plotted on the normal distribution Q-Q plot closely follow a straight line, even at the ends of the line, then the data may be assumed to be normally distributed. If the data points deviate substantially from a linear line, then the data are not normally distributed.





Extreme value (outlier) in box-and-whisker plot was assigned during data validation. Original sample result was 2.97 J (estimated detect). Data validation qualifier was assigned at 6.72 U (non-detect) based on blank contamination.



For more information on these three plots consult Guidance for Data Quality Assessment, EPA QA/G-9, pgs 2.3-1 through 2.3-12. (http://www.epa.gov/quality/qa-docs.html).

Tests for Methylene chloride

A goodness-of-fit test was performed to test whether the data set had been drawn from an underlying normal distribution. The Shapiro-Wilk (SW) test was used to test the null hypothesis that the data are normally distributed. The test was conducted at the 5% significance level, i.e., the probability the test incorrectly rejects the null hypothesis was set at 0.05.

NORMAL DISTRIBUTION TEST	
Shapiro-Wilk Test Statistic	0.302
Shapiro-Wilk 5% Critical Value	0.905

The calculated SW test statistic is less than the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the data are normal, or in other words the data do not appear to follow a normal distribution at the 5% level of significance. The Q-Q plot displayed above should be used to further assess the normality of the data.

Upper Confidence Limit on the True Mean

Two methods were used to compute the upper confidence limit (UCL) on the mean. The first is a parametric method that assumes a normal distribution. The second is the Chebyshev method, which requires no distributional assumption.

UCLs ON THE MEAN	
95% Parametric UCL	2.3618
95% Non-Parametric (Chebyshev) UCL	3.0293

Because the data do not appear to be normally distributed according to the goodness-of-fit test performed above, the non-parametric UCL (3.029) may be a more accurate upper confidence limit on the true mean.

MARSSIM Sign Test
The Sign test was performed in accordance with the guidance given in section 8.3.2 of MARSSIM. Each measurement was subtracted from the action level to obtain *n* differences $d_i = AL - X_i$. Any differences of zero were discarded from consideration and the sample size was reduced accordingly. The test statistic S+ was calculated by counting the positive differences. S+ was then compared with the critical value *k*, which was obtained from Table I.3 in Appendix I of MARSSIM.

If $S+ > k$, then the null hypothesis is rejected.

MARSSIM SIGN TEST		
Test Statistic S+	**95% Critical Value**	**Null Hypothesis**
20	14	Reject

The test rejected the null hypothesis for methylene chloride that the mean value at the site exceeds the threshold, so conclude the **site is clean**.

2-Methylphenol (o-cresol)

Data Analysis for 2-Methylphenol (cresol, o-)
The following data points were entered by the user for analysis.

2-Methylphenol (cresol, o-) (µg/kg)										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	103	103	103	104	104	104	104	104	104	105
10	105	105	106	108	108	108	108	109	112	113

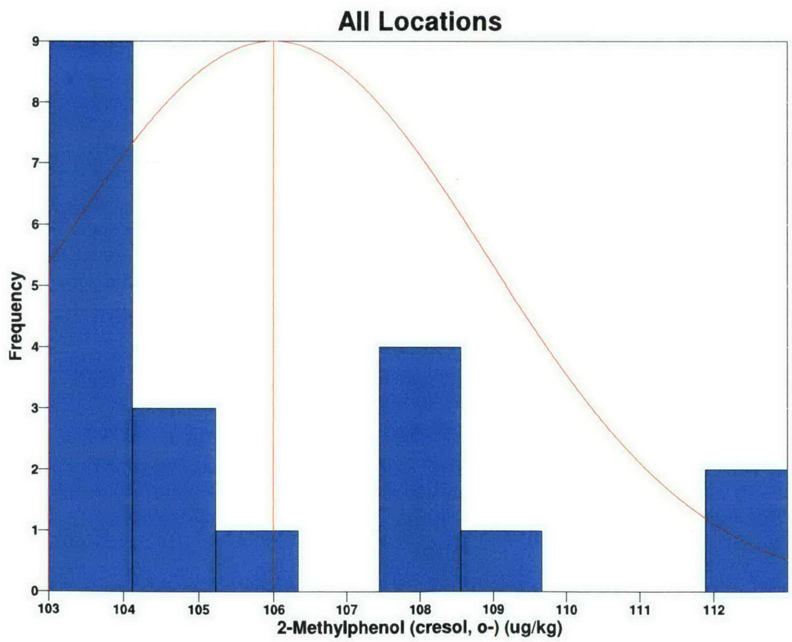
SUMMARY STATISTICS for 2-Methylphenol (cresol, o-)								
n	20							
Min	103							
Max	113							
Range	10							
Mean	106							
Median	105							
Variance	8.6316							
StdDev	2.938							
Std Error	0.65695							
Skewness	1.1207							
Interquartile Range	4							
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
103	103	103	104	105	108	111.7	113	113

Data Plots
Three graphical displays of the data are shown below: the Histogram, the Box and Whiskers plot, and the Quantile-Quantile (Q-Q) plot.

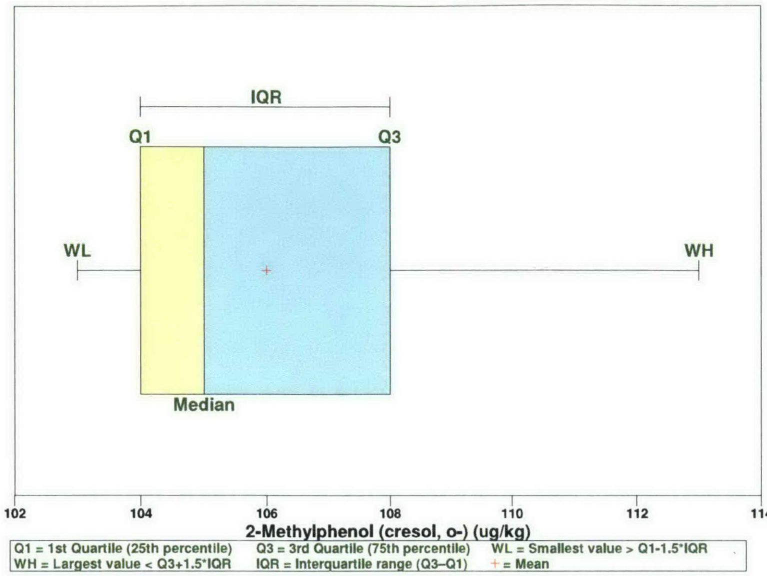
The Histogram is a plot of the fraction of the n observed data that fall within specified data “bins.” A histogram is generated by dividing the x axis (range of the observed data values) into "bins" and displaying the number of data in each bin as the height of a bar for the bin. The area of the bar is the fraction of the n data values that lie within the bin. The sum of the fractions for all bins equals one. A histogram is used to assess how the n data are distributed (spread) over their range of values. If the histogram is more or less symmetric and bell shaped, then the data may be normally distributed.

The Box and Whiskers plot is composed of a central box divided by a line, and with two lines extending out from the box, called the "whiskers". The line through the box is drawn at the median of the n data observed. The two ends of the box represent the 25th and 75th percentiles of the n data values, which are also called the lower and upper quartiles, respectively, of the data set. The sample mean (mean of the n data) is shown as a "+" sign. The upper whisker extends to the largest data value that is less than the upper quartile plus 1.5 times the interquartile range (upper quartile minus the lower quartile). The lower whisker extends to the smallest data value that is greater than the lower quartile minus 1.5 times the interquartile range. Extreme data values (greater or smaller than the ends of the whiskers) are plotted individually. A Box and Whiskers plot is used to assess the symmetry of the distribution of the data set. If the distribution is symmetrical, the box is divided into two equal halves by the median, the whiskers will be the same length, and the number of extreme data points will be distributed equally on either end of the plot.

The Q-Q plot graphs the quantiles of a set of n data against the quantiles of a specific distribution. We show here only the Q-Q plot for an assumed normal distribution. The pth quantile of a distribution of data is the data value, x_p, for which a fraction p of the distribution is less than x_p. If the data plotted on the normal distribution Q-Q plot closely follow a straight line, even at the ends of the line, then the data may be assumed to be normally distributed. If the data points deviate substantially from a linear line, then the data are not normally distributed.

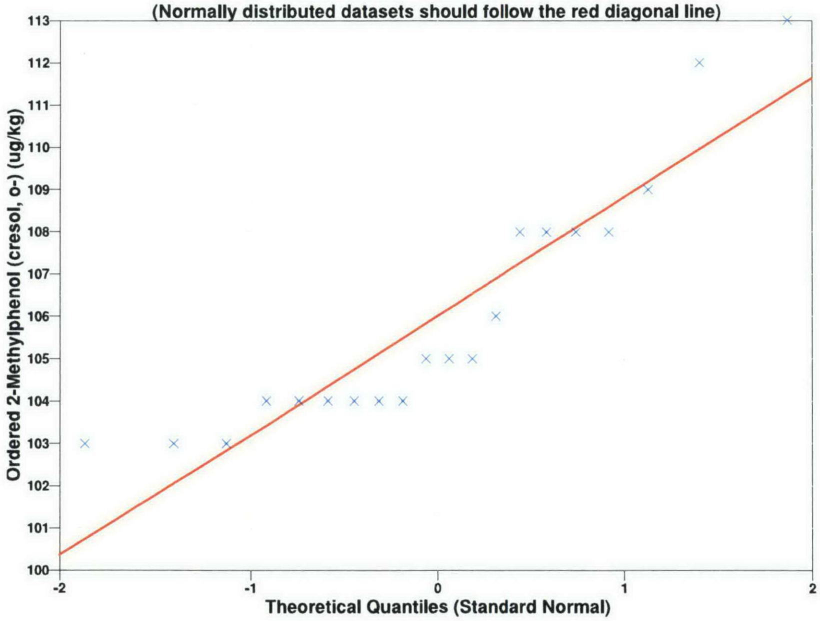


Box and Whisker Plot



Quantile - Quantile Plot

(Normally distributed datasets should follow the red diagonal line)



For more information on these three plots consult Guidance for Data Quality Assessment, EPA QA/G-9, pgs 2.3-1 through 2.3-12. (http://www.epa.gov/quality/qa-docs.html).

Tests for 2-Methylphenol (cresol, o-)

A goodness-of-fit test was performed to test whether the data set had been drawn from an underlying normal distribution. The Shapiro-Wilk (SW) test was used to test the null hypothesis that the data are normally distributed. The test was conducted at the 5% significance level, i.e., the probability the test incorrectly rejects the null hypothesis was set at 0.05.

NORMAL DISTRIBUTION TEST	
Shapiro-Wilk Test Statistic	0.8482
Shapiro-Wilk 5% Critical Value	0.905

The calculated SW test statistic is less than the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the data are normal, or in other words the data do not appear to follow a normal distribution at the 5% level of significance. The Q-Q plot displayed above should be used to further assess the normality of the data.

Upper Confidence Limit on the True Mean
Two methods were used to compute the upper confidence limit (UCL) on the mean. The first is a parametric method that assumes a normal distribution. The second is the Chebyshev method, which requires no distributional assumption.

UCLs ON THE MEAN	
95% Parametric UCL	107.14
95% Non-Parametric (Chebyshev) UCL	108.86

Because the data do not appear to be normally distributed according to the goodness-of-fit test performed above, the non-parametric UCL (108.9) may be a more accurate upper confidence limit on the true mean.

MARSSIM Sign Test
The Sign test was performed in accordance with the guidance given in section 8.3.2 of MARSSIM. Each measurement was subtracted from the action level to obtain *n* differences $d_i = AL - X_i$. Any differences of zero were discarded from consideration and the sample size was reduced accordingly. The test statistic S+ was calculated by counting the positive differences. S+ was then compared with the critical value *k*, which was obtained from Table I.3 in Appendix I of MARSSIM.

If $S+ > k$, then the null hypothesis is rejected.

MARSSIM SIGN TEST		
Test Statistic S+	**95% Critical Value**	**Null Hypothesis**
20	14	Reject

The test rejected the null hypothesis for 2-Methylphenol (cresol, o-) that the mean value at the site exceeds the threshold, so conclude the **site is clean**.

3+4 Methylphenol (m+p cresol)

Data Analysis for 3+4 Methylphenol (cresol, m+p)
The following data points were entered by the user for analysis.

3+4 Methylphenol (cresol, m+p) (µg/kg)										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	103	103	103	104	104	104	104	104	104	105
10	105	105	106	108	108	108	108	109	112	113

SUMMARY STATISTICS for 3+4 Methylphenol (cresol, m+p)								
n				20				
Min				103				
Max				113				
Range				10				
Mean				106				
Median				105				
Variance				8.6316				
StdDev				2.938				
Std Error				0.65695				
Skewness				1.1207				
Interquartile Range				4				
Percentiles								
1%	5%	10%	25%	50%	75%	90%	95%	99%
103	103	103	104	105	108	111.7	113	113

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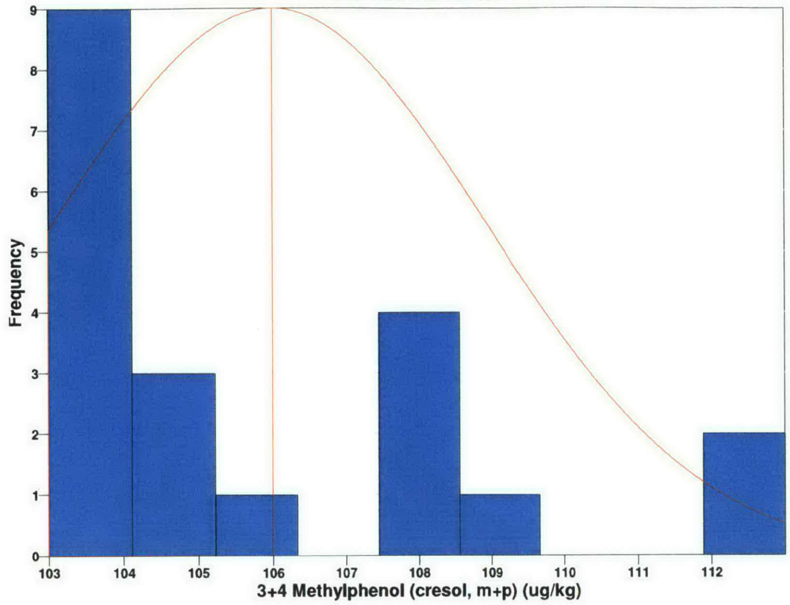
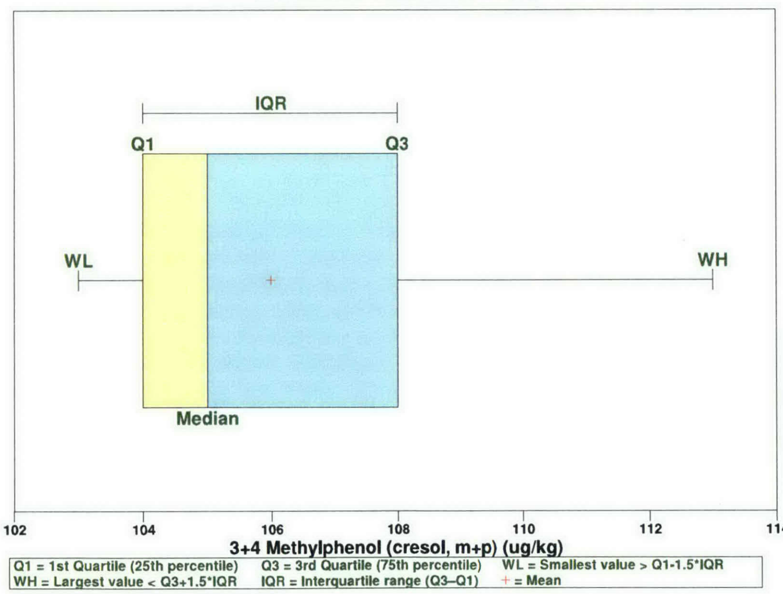
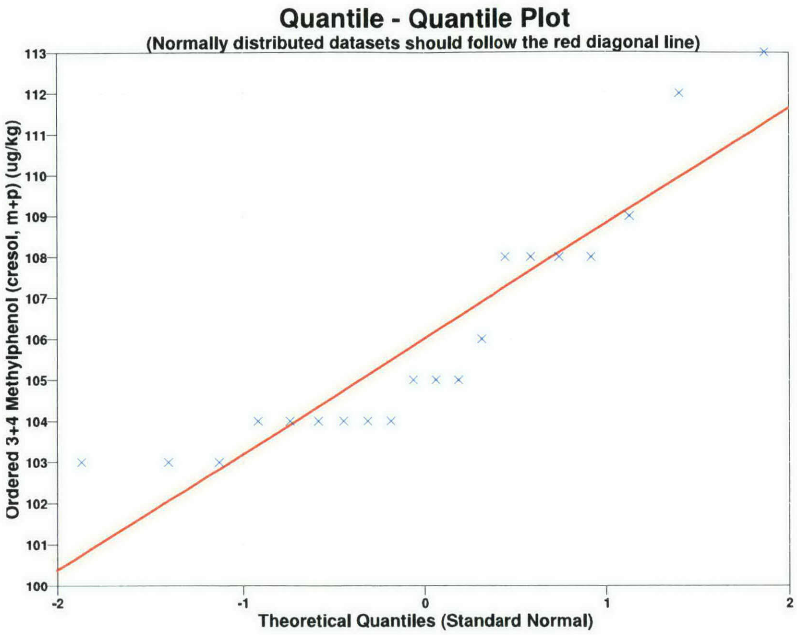
All Locations



Box and Whisker Plot





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